ART. XIX.—*Hospitals and Hospital Construction.*

1. *Étude sur les Hôpitaux considérés sous la Rapport de leur Construction, de la Distribution de leurs Batiments, de l'Ameublement, de l'Hygiène, et du Service des Salles de Maladies.* Par M. ARMAND HUSSON, Directeur de l'Administration Générale de l'Assistance Publique. Paris, 1862.
2. *Rapport sur les Hôpitaux Civilis de la Ville de Londres au point de vue de la Comparison de ces Etablissements avec les Hôpitaux de la Ville de Paris.* Par M. BLONDET, et M. S. SER, de l'Administration de l'Assistance Publique. Paris, 1862.
3. *Sixth Report of the Medical Officers of the Privy Council, with Appendix*, 1863. London, 1864.
4. *Projet de Construction du Nouvel Hôtel-Dieu de Paris. Rapport fait au Conseil Municipal de Paris.* Par AMBROISE TARDIEU. pp. 44. Paris, 1865.
5. *Plain Concise Practical Remarks on the Treatment of Wounds and Fractures; with an Appendix on Camp and Military Hospitals, principally designed for the Use of Young Military and Naval Surgeons in North America.* By JOHN JONES, M. D., Prof. of Surg. in King's College, New York. New York, 1775.
6. *Medical Sketches of the Campaigns of* 1812, '13, '14; *to which are added Surgical Cases, Observations on Military Hospitals, and Flying Hospitals attached to a Moving Army.* By JAMES MANN, M. D., A. A. S., &c. pp. 318. Dedham, 1816.
7. *Société de Chirurgie de Paris; Discussion sur l'Hygiène et la Salubrité des Hôpitaux.* pp. 137. Paris, 1865.
8. *Notes on Hospitals.* By FLORENCE NIGHTINGALE. Third edition. pp. 187. London, 1868.

IN the first lines of the preface to her admirable work, *Notes on Hospitals*, Miss Nightingale remarks: "It may seem a strange principle to enunciate as the very first requirement in a hospital, that it should do the sick no harm." It does, indeed, seem strange that in this day of the universal recognition of the necessity of hospitals, and their rapid multiplication, an able and experienced writer should solemnly and emphatically assert, as the first principle in their construction, the simple and unquestioned axiom, that they do the sick no harm. Is it really true that, after centuries of experience, we have become so regardless of the true purpose and intent of hospitals that we need to be admonished of the real object of such institutions? Must we be reminded anew that hospitals are designed for the cure of the sick? Whoever views this subject in the light of experience and observation must acknowledge that Miss Nightingale has stated a truth which even now is full of significance, and deserving of the most serious consideration. It is too true, as she remarks, "that the actual mortality in hospitals, especially in those of large crowded cities, is very much higher than any calculation founded on the mortality of the same class of diseases among patients treated out of hospitals would lead us to expect." This is especially the case with those diseases classified under the general head of typhoid; as erysipelas, pyæmia, continued fevers, diarrhœal affections, etc., most of which are now understood to arise from, or be aggravated by, local causes. All large metropolitan hospitals always show an excess of deaths from these diseases. But it is not only by delaying the recovery of the sick that hospitals fail to answer their humane purposes; they may, by their unhealthiness, expose their inmates to new and fatal diseases. There are many instructive examples of this latter defect in our hospitals. Indeed it is not an infrequent occurrence that patients enter general hospitals with simple and curable diseases, but contract other maladies of a more fatal character, of which they die. The aggregate mortality of this class from fever and typhoid affections, in large hospitals, is not inconsiderable. Every lying-in ward, and, in fact, nearly every ward of general hospitals, affords striking proofs of this statement. Every life thus sacrificed is needlessly and criminally destroyed.

Hospitals were instituted at an early period, and were at first united, for the most part, to monasteries, and were essentially religious organizations. It was not until the twelfth century that they began to assume much importance, and take a proper rank as public institutions. But even then no especial attention seems to have been given to their construction and management. The style of architecture was adapted to that of the age in which they were built, with but little regard to the special purposes of the building. Hospital endemics were of constant occurrence, and so great was the annual mortality, even of the best hospitals, that these institutions came to be characterized by the most disparaging epithets. It was not until near the close of the last century that any enlightened discussion occurred as to the causes of this excessive mortality, and that an adequate remedy was suggested.

One of the first students of an improved hospital construction was an American surgeon. To Dr. John Jones, of Revolutionary memory, the friend and professional adviser of Washington and Franklin, belongs the honour of *first* advocating and practically demonstrating an improved system of hospital construction and management. His attention was called to the subject while pursuing his studies in Europe, about the middle of the last century, and his observations upon the condition of the great hospitals of Paris and London show how thoroughly he appreciated their defects. In the work above quoted he says—

> "To those who are unacquainted with the subject in question it will, doubtless, appear a very extraordinary assertion that there is not at present in the capital of the kingdom (London) a single hospital constructed upon proper medical principles. * * * *
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> "In Paris it is supposed that one-third of all who die there die in hospitals. The Hôtel-Dieu, a vast building situated in the middle of that great city, receives about twenty-two thousand persons annually, one-fifth of which number die every year. It is impossible for a man of any humanity to walk through the long wards of this crowded hospital without a mixture of horror and commiseration at the sad spectacle of misery which presents itself."

He concludes that the excessive mortality in hospitals of large cities as compared with those of small towns is due to overcrowding and defective ventilation, and makes the following very pertinent remarks :—

> "A false economy has universally prevailed in the structure of hospitals for the sick; for those that have hitherto had a principal direction, both in the architecture and management of them, have confined their views entirely to objects of conveniency, cheapness, and ornament. * * * *
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> "In short," he says, "the physician and architect have, generally, two very opposite and incompatible views; the latter laying out his plan so as to contain the greatest number of persons in the least possible space, whereas the former always aims at having the utmost room which is consistent with use and conveniency."

It will ever redound to the honour of this distinguished surgeon, not only that he correctly interpreted the faults of hospital construction at that early period, but that he devised plans for the old New York Hospital upon the pavilion model, and secured its construction with all the appointments of the most approved hospitals of our time. This hospital was begun in 1771, and was burned, when nearly completed, in 1775. He says of its architecture—

> "It is to be hoped that the hospital lately built in the city of New York will have fewer objections to its plan than any hospital hitherto constructed; the principal wards, which are to contain no more than eight beds, were thirty-six feet in length, twenty-four wide, and eighteen high; they are all well ventilated, not only from the opposite disposition of the windows but proper openings in the side walls, and the doors open into a long passage or gallery thoroughly ventilated from north to south."

At a somewhat later period the subject of improved hospitals began to attract attention in France. And it is interesting to notice that those who wrote upon this subject made their first observations, like Dr. Jones, in the Hôtel-Dieu, and arrived at nearly the same conclusions as to the remedy.

The ancient Hôtel-Dieu of Paris, one of the oldest European hospitals, had long been notorious for its excessive mortality. It was so arranged that there was direct communication between the wards occupied by five hundred and fifty patients. The whole number of beds was twelve hundred, but this by no means measured the capacity of the hospital; by crowding, these beds were made to accommodate two thousand, five thousand, and even seven thousand sick people. In 1515, the multiple beds contained eight to twelve patients each; in 1530, there were relays of patients to each, those not in bed waiting their turn on forms. In 1772 this hospital was burnt, and with it a number of patients, and public opinion demanded its removal. After much discussion a commission of the Academy of Sciences was appointed to consider the questions raised as to the removal or reconstruction of the Hôtel-Dieu. This commission embodied some of the most eminent names in the scientific world, as La Place, Lavoisier, Bailly, Daubenton, &c. The problem presented to these practical minds, and the data given for its solution, were of such a character as to call forth all their energy. They submitted their final report in 1788, embracing principles and plans for the reconstruction of Hôtel-Dieu.

The groundwork of the reform which they proposed was, first, the separation of the sick from the administration; second, the exposure of the wards to the currents of air, and to the sunlight; and, third, a larger surface area and cubic air space to the individual patient. In these three propositions we have embodied the true principles of hospital construction, and all the discussions of modern times, and all experience and observations have only the more confirmed and established them.

In the detail of their plans of reconstruction of the Hôtel-Dieu the commission describe in nearly exact terms the plan of the Lariboisière Hospital of Paris, the most perfect of modern hospitals as regards its general plan.

During the war of 1812 the subject of hospital construction attracted much attention, and Surgeon-General Tilton proposed what Dr. Mann very correctly terms "a novel plan." Hospitals were to be built of logs, one story, without floor, a fireplace without chimney in the centre. Hospitals constructed on this plan were found to be expensive, and they were built to but a very limited extent. Dr. Mann's own plan of hospitals is much better. He proposed to have them one story; the wards accommodating 20 patients, 24 × 30, and 11 feet high, with east and west exposure; a covered corridor 12 feet wide, &c. This plan gave but 396 cubic feet of air space to each patient, and effectually closed one side against all ventilation. It is evident that little improvement in hospitals had been made in this country from the Revolution to the second war with Great Britain.

For the succeeding half century but little attention was given to improvement in hospital construction and management. The principles laid down by the commission of the Academy of Sciences of Paris seem to have attracted no notice and to have found no expression. In 1846 the establishment of the Lariboisière of Paris, was decided upon, and the plans of the commission were reproduced, and in the main followed. This hospital represents an era in the science of hospital construction. Whatever may be its defects they are due rather to faults in detail than to original principles, and cannot militate against the grand idea which underlies it.

It is not a little remarkable that within the last year or two the question of reconstructing the Hôtel-Dieu has again been raised, and the whole subject of hospital construction has been thoroughly canvassed by the *Société de Chirurgie* of Paris, resulting in a confirmation of the report of the Academy of Sciences of 1788.

In Germany great interest is now manifested in hospital construction. The work of Dr. Oppert, of Berlin, embodies the most approved views.

In Great Britain the highest order of architectural talents is now devoted to this subject, and with the best results. The fearful mortality which resulted from the agglomeration of the sick in the Crimea in ill-constructed barracks, and the great improvement which followed the introduction of well-arranged and properly appointed hospitals stimulated inquiry into hospital construction. In this inquiry Miss Nightingale took the lead, and it is mainly due to her startling developments of the causes of this terrible mortality, viz., hospital mismanagement; and the fervor of her appeals in behalf of improved hospital construction and management, that practical minds both in and out of the medical profession have recently given to this subject so much thought and study. And to her work on hospitals, more than to any or all other sources, is the world indebted for the magnificent hospital system now universally recognized, which is giving to the sick-poor retreats so beautiful, so pleasant, and so healthy.

In this country the subject of improved hospital architecture has not attracted much notice until recently. All our modern hospitals are constructed upon old plans, and give the same unfavourable results in practice. The first systematic effort to establish a hospital in accordance with the demands of sanitary science was made by the municipal government of Boston, Massachusetts. In establishing a free city hospital, in 1861, the authorities advertised for plans, and a large number were submitted. From these they selected one which carries out to the fullest extent the latest and most improved ideas of hospital construction, viz., the pavilion plan. More recently the Commissioners of Emigration of New York have erected upon Ward's Island a large hospital arranged in pavilions. At Providence, Rhode Island, a third hospital is being constructed upon the same plan, as is also the German hospital of New York, now being built, and several other hospitals projected in various parts of the country.

During the war just closed great attention was paid to the erection of suitable military hospitals. All of the hospitals erected were upon the pavilion plan, and admirably did they answer their purpose. At one period there were not less than two hundred general hospitals under the medical department of the army, accommodating from two hundred to four thousand patients each. To Dr. William A. Hammond, then Surgeon-General, is due the honour of introducing and enforcing the latest improvements in hospital construction. The country owes him a lasting debt of gratitude for the enlightened zeal with which he administered, often under great embarrassments, this department of the army medical service.

The views at present entertained of the principles of hospital construction may best be stated by examining in some detail the more important questions involved in the erection of a hospital. On these points the above works are more or less complete, and we shall limit this review to the statement of the general conclusions therein contained.

The first question which those engaged in the establishment of a hospital have to consider is the location. Shall it be located in the city or country? Much attention has recently been given in England to the comparative healthfulness of hospitals located in populous towns and in the open country. Statistics of mortality from these different institutions have been collected and compared, and various deductions have been drawn therefrom. In 1863 the question took a thoroughly practical form, and the results of the investigation are worthy of the most serious consideration.

St. Thomas' Hospital, which had for six centuries occupied a position at the south end of London Bridge, was about to give up its ancient site, and seek a new location. A contest immediately arose among the parties interested in the hospital, some contending that it should seek a purely country location, while others were equally strenuous in their efforts to secure a site not far removed from that which it was about to abandon. It was alleged by the first party that the great desideratum in the location of a hospital was the selection of a site far from the pollution of a city atmosphere, and abundantly supplied with pure air. The second party contended that the value of a hospital depended upon its accessibility by that class of sick persons for whose relief it was erected; if, therefore, a hospital designed for any class of people living in a populous town should be located at a distance in the country, whatever advantages it might have in salubrity, it would be of little or no service to those who were expected to occupy its wards.

The question became a matter of so much public interest that the Privy Council appointed a commission to examine critically the hospitals of Great Britain, Scotland, and France, with a view to determine definitely the comparative mortality of city, town, and country hospitals, and "to ascertain the influence of different sanitary circumstances in determining (in different hospitals, as compared with one another and where practicable, with private practice) the more or less successful results of medical and surgical treatment."

After a most careful and searching investigation the commission came to the following conclusions:—

> "English rural hospitals have acquired, on false grounds, a reputation for comparative healthiness; by their regulations, their practice, or their position, they receive habitually a far less serious class of cases than is admitted into the hospitals of London and other large towns; this difference in the quality of the practice is much greater in respect of medicine than of surgery, but is considerable even as regards surgery; the result is marked lowness of death rates, even, in many cases, in the presence of a high degree of hospital insalubrity."

In giving their conclusion a practical application they make the following statement:—

"Suppose it possible to transport St. Bartholomew's Hospital, as it now is, and with its present supply of patients, from the heart of the city into the heart of the country, what would be the result on the prospects of individual patients? Our deliberate opinion is that the effect, if any, would be trifling. That there might be some slight variation in the mortality may or may not be probable; but that the prevalence of hospital disease would be much decreased, that operations on given cases would be more likely to succeed, or that the period of recovery of given cases would be much abridged, we do, judging from the evidence before us of the state of things in hospitals variously circumstanced, as far as situation goes, utterly disbelieve. In fact, we have no evidence which shows that any change would be wrought in any of these three particularly."

Notwithstanding the high authority and positive conclusions of this commission, its decision, so contrary to all experience and belief, is not to be accepted as final. A careful examination of the report and the statistics which form its groundwork, cannot fail to convince the reader that the evidence adduced is after all not satisfactory. It is for the most part of a negative character; there is wanting that perfect analogy in comparison essential to positive results. It cannot be denied that the country has the purer atmosphere, the greater facilities for drainage, a better exposure to sunlight and to winds. It is only in the danger of unhealthy emanations from the soil that the city has preference over the country; but even in this respect there is a full compensation on the part of the city in the poisonous effluvia from the streets, sewers, and unclean courts.

Happily it is a matter of little consequence how we decide the question of the comparative healthiness of city and country hospitals, for another element of equal importance to salubrity must enter into our calculation in selecting a site, viz., accessibility.

No fact has been more rigidly demonstrated during the late war than that transportation of acute, medical, and surgical cases is, in a given degree, injurious. A hospital to be in the highest degree serviceable must be located near that class of people whom it is designed to benefit. In the erection of hospitals for small towns a country site may readily be selected which will not place the hospital beyond the limits of easy transportation. But it rarely happens, that in the selection of a site for a hospital intended for the treatment of the acute diseases of any class of people of a populous town, salubrity and accessibility so exactly correspond as to leave nothing to be desired. One or the other of these conditions must take precedence, and we are sustained by the united testimony of the ablest writers on hospital construction in the statement that the former must, to some extent, be sacrificed to the latter.

Says Miss Nightingale, a strenuous advocate of country hospitals, when it is practicable to properly locate them—

"It is, obviously, of no use to build a hospital in the best air in the world if neither patients nor medical officers can get to it. It is only in applying common sense to such a question, and by always giving a preponderance to the condition of highest importance, namely, pure air, when other conditions can be at the same time reasonably obtained, that the best will be done for the sick."

* * * "All are agreed that fresh country air is better for the sick than impure town air, and hence the whole question narrows itself within the compass of one of the conditions enumerated above, namely, accessibility."

The medical officer of the Privy Council, Mr. Simon, in commenting upon the report of the commission of inquiry into the salubrity of English hospitals, remarks:—

Primarily the site of every hospital must be decided by the site and distinction of the population to which it has to minister; and if, as too commonly happens, reasons of trading, convenience, or other reasons have determined a population to settle itself in a site of comparative insalubrity, the hospital which has to minister to that population can seldom do otherwise than to some extent share the same lot. All that it has then to do is to make the best settlement which is possible within the limited area of choice."

When the question of the removal of the site of St. Thomas's Hospital, London, was first raised, its Board of Governors sought the advice of its medical officers as to "whether town or country should be preferred for the new hospital site." Though these gentlemen were divided in opinion on the general question of the comparative healthiness of country and town hospitals, they advised in the following terms:—

"Supposing two otherwise thoroughly well-conditioned hospitals, one in London, the other in the country; some of us believe, while others of us do not believe, that in the results of medical and surgical treatment the country hospital would have an appreciable superiority of success. If, however, we, in this respect for argument's sake, adopted, as though it were unanimous, the most sanguine belief which any one of our members entertains, our practical conclusion (that St. Thomas's Hospital ought not to be moved into the country) would be unchanged; for unanimously we should be of opinion that the advantages of the country hospital would be purchased at far too dear a price, when, in obtaining them, the hospital must be made inaccessible to the sufferers who most urgently require it, and when the present system of professional attendance must be changed in essential particulars."

It is interesting to notice in this connection the final action of the governors of St. Thomas's Hospital. Although a sub-committee of their own number reported in favour of selecting a rural site, and removing the hospital beyond the city limits, their conclusions were rejected by the full Board, and the hospital has been re-located within convenient distance of the district of London, the population of which it serves.

The bearing of these facts upon the question of locating a hospital designed for the relief of acute, medical, and surgical cases occurring among any part of the population of large cities, is important. A hospital located *beyond* the corporate limits of the city could not, in many instances, be available for the treatment of acute disease occurring among any class of its people. If such a hospital were, indeed, located in the adjacent country, it would require a house of reception in the city for severe cases, and this latter would soon become the more important institution, while the former would gradually assume only the status of a convalescent hospital.

It being determined, therefore, to locate the hospital within the city limits for the purpose of rendering it accessible, we have a not less important question to decide than that already considered, namely, the selection of a proper site with a limited means of choice. As, however, the area of many large towns of this country presents every variety of hill, valley, and plateau, and, further, the city railroads render most of this territory readily accessible, this problem of selecting a proper location within the town limits admits of a comparatively easy solution. A site can be chosen, and doubtless secured, which will for a considerable period present equal advantages with the best country location as regards pure air, abundant ventilation, and unobstructed sunlight. St. Luke's Hospital, New York, the Episcopal Hospital, Philadelphia, and others, have for several years enjoyed all the advantages of a country location, and are accessible to the sick-poor. It must be remembered, however, that within a given, but not remote period, every available portion of the area of most of our large towns is to be occupied by a dense population, and care should be taken to secure a sufficient amount of land to prevent such encroachments as in time would seriously impair its location.

The immediate choice of a site should be governed by its accessibility, the future character of the neighbourhood, its elevation, its soil, its facilities for surface and underground drainings, the amount of land purchasable, etc. Care should be taken to guard against the neighbourhood of unwholesome establishments, as fat boiling, slaughter-houses, gas-houses, etc. Elevated grounds should be chosen, not only for greater purity of air, but for better facilities of drainage and sewerage. A soil should be selected porous and non-retentive of moisture; hence, clay soil should be avoided. Perfect sewerage and drainage is an absolutely essential condition in the groundwork of a hospital, and to secure this advantage there must be proper descent for a rapid discharge and removal of sewage. It is of prime importance also to guard against future encroachments of population or business, and therefore a sufficient amount of land should be obtained to preserve to the hospital the free circulation of air and unobstructed sunlight.

Mr. Simon (op. cit.), remarks:—

> "Where the hospital is for a town, sites must be compared with special regard to their respective degrees of spaciousness and ventilability; and in order to get more of those advantages, so far as the pursuit of them consists with the due accessibility of the hospital, preference commonly ought to be given either to the outskirts, or to the largest interior spaces of towns. Except for special reasons to the contrary, hill-tops are to be preferred to hill-slopes, and either of them greatly to valley-bottoms. And the cleaner the neighbourhood the better."

In selecting a site for a hospital within the corporate limits of towns, it must be constantly borne in mind that at no very distant day such hospital and grounds are to be enveloped in a dense and overcrowded population. The New York Hospital, and, to some extent, the Pennsylvania Hospital, in Philadelphia, originally located far from the centres of business, in the free and open country, but still on the line of city growth, present examples to which we should give heed. On every side, business with covetous grasp presses upon them, and these once quiet and secluded precincts are for evermore disturbed by the roar and din of traffic, and the atmosphere is polluted by the emanations from the crowded tenements, and the unclean courts and streets. Invaluable as have been and are the services of these noble institutions to the unfortunate of the large territory which surrounds them, there can be no doubt that their future success would be much greater could they command a large open area upon all sides.

In the location of recent town hospitals, the Boards of Governors and Trustees have been properly impressed with the importance of securing an ample amount of grounds. The trustees of the Free City Hospital, Boston, secured six acres and seven-tenths, and remark:—

> "We consider the dimensions of this area none too large, and quite consistent with a judicious economy. * * * The importance of open spaces for light and the free circulation of air from the water is too obvious to dwell upon, and we think there can be but one opinion as to the propriety of securing, while in our power, all the area that we need."

The Rhode Island Hospital, Providence, has an area of fifteen acres.

The Episcopal Hospital, Philadelphia, erected on high ground in the suburbs of the town, secured two squares of six acres each, amounting to twelve acres.

The Lariboisière Hospital, Paris, occupies twelve to fifteen acres.

The New Herbert Hospital, Woolwich, England, has an area of seven acres for seven pavilions.

The New St. Thomas' Hospital, London, is to occupy fifteen to eighteen acres, having seven pavilions.

The German Hospital, New York, has secured one square, and propose to add several lots on an adjoining square.

Much attention has recently been given to the capacity of civil hospitals in its relation,

1st. To facility of administration, and

2d. To the effect of the aggregation of sick upon the mortality.

The true objects to be obtained in administration, are economy and efficiency. To secure these ends, much will always depend upon the character of officers and subordinates, whatever may be the peculiarity or perfection of the hospital arrangements. Fonblanque truly observes, "It is not the *personnel*, but the *morale*, upon which a sound administration hinges; a system based on the personal integrity of its agents." But it is nevertheless true, that the appointments of a hospital may be so imperfect that the greatest vigilance and energy on the part of agents shall not secure a high, or even a moderate degree of either economy or efficiency.

The first element of failure in hospital management, is due to a too-extended jurisdiction. The larger the number of patients, the greater the number of details and the more complicated the system. Beyond a certain limit the machinery becomes cumbersome, and ceases to feel the momentum of the central, governing power. Wastefulness succeeds to economy, tardiness to promptness, recklessness to efficiency. We conclude, therefore, that for economical and efficient administration a limited capacity is essential, and in this we are borne out by experience. And we should reach the same conclusion, did we have regard to the effect of the aggregation of sick persons upon the health of the hospital. If proper hospital management requires a certain fixed area populated by a fixed number of sick, any increase of that number must tend at once to the vitiation of the atmosphere of that area, and sooner or later seriously affect the healthiness of the place. Miss Nightingale very truly remarks:—

> "It is a well-established fact that, other things being equal, the amount of sickness and mortality on different areas bears a ratio to the degree of density of the population. Why should undue agglomeration of the sick be any exception to this law? Is it not rather to be expected that the constitutions of the sick people being more susceptible than those of healthy people, they should suffer more from that cause?"

Observation and experience coincide in establishing the fact that civil hospitals having not more than six hundred and fifty patients under one management, are best conducted so far as regards strict economy and real efficiency. And a due regard to the effects of the aggregation of the sick upon the health of a hospital confirms the proposition. If an extreme approved limit were required, we should fix it at one thousand patients. For, as Miss Nightingale says, when the machinery begins to multiply itself, it becomes unwieldy.

The governing principle in hospital construction, until a recent period, was the arrangement of the wards and buildings around a central stem or axis which became the medium of ventilation. This central shaft was either a staircase or a series of corridors, or, finally, a chapel. In the elaboration of this idea we obtain all the variety of plans which characterize the older hospitals.

The first and most prominent defect in all these plans is the utter impossibility of securing thorough ventilation. Through the medium of the stairways and corridors wards are directly ventilated into each other, and the air of one contaminates the other. Besides, too frequently, these central shafts have no special means of independent ventilation, and hence become great reservoirs of foul air. It is perfectly certain that in time the air, and even the walls, of such hospitals must become saturated with the poisonous emanations of the sick, and react most unfavourably upon the inmates. It is to this source that we must trace hospital endemics, such as pyæmia, erysipelas, diarrhœa, typhoid and typhus fevers, which are so rife and so fatal in older hospitals.

Another defect noticeable in these plans is the tendency to surround the wards with many of the accessory rooms, thus shutting them still more within the central portion, and depriving them of proper external means of ventilation.

Again, these plans lead to an excessive aggregation of the sick upon a given area. Stories are superadded and wards multiplied until the population to the surface-area exceeds many times a proper standard. All the evils of overcrowding, one of the most potent sanitary defects of towns, are realized, often in a fearful degree, in many of the older hospitals. All hospitals of this construction are not by any means equally faulty; many of them, indeed, by unusual extension and great care in preventing overcrowding maintain a fair degree of salubrity. But sooner or later, without exception, they give rise to some of the pernicious hospital endemics already mentioned, and demonstrate beyond question that the air within is becoming charged with impalpable and imperceptible miasms.

The fault is in the groundwork of the plans; they do not provide for the constant and thorough removal of foul air, and an abundant supply of fresh air. Mr. Roberton, of Manchester, a scientific expert in all that pertains to hospital construction, says that such hospitals labour under:—

> "First, the difficulty, owing to faulty construction, of securing a free circulation through the wards and continued renewal therein of the external atmosphere; and, secondly, the intimate connection existing between the different wards in each story by means of doors and passages, and between the different stories by inside stairs—an arrangement which favours the rapid diffusion over the house of the foul air continually being generated in every one of the wards, and the creation consequently of a hospital miasm."

Miss Nightingale says:—

> "One of the most common mistakes in hospital plans, even in some of the most recent of those I have seen, is mixing up together, in the same block, sick wards and administration offices of all kinds. It need hardly be pointed out that such an attempt must necessarily lead to a very complicated structure, containing large wards, and an indefinite number of rooms of different sizes, all connected by passages and stairs more or less dark, badly ventilated, and diffusing a common atmosphere throughout the building."

The all-important question which presents itself to students of hospital architecture is, how can these original defects in construction be remedied? The Committee of the French Academy of Sciences, appointed to report a plan of rebuilding the Hôtel-Dieu, already referred to, met this question and gave it a practical solution as early as 1778. But little improvement, except in details, has been made upon their plans during the past three-quarters of a century. It will be instructive therefore to notice briefly some of the leading points of their report.

1st. They proposed the isolation of the patients from the administration by the erection of separate and independent buildings.

2d. They proposed that a building for the reception of patients should be located in the front ground; the administration buildings, containing thê offices, kitchen, apothecary's department, &c., in the centre, and the pavilions at the extremities.

3d. They proposed that the pavilions should be parallel buildings, three stories in height, 24 feet wide by 168 in length; the ends of the buildings to the extent of 30 feet were to be wider, and contain all the accessory rooms of the wards; the height of the wards was to be 14 to 15 feet; the windows were to be placed above the beds and extend to the ceiling.

4th. They proposed that each ward should contain 34 to 36 beds, each pavilion 102 to 108 beds, and that each individual ward should have its baths, its latrines, its kitchen, its stove, its scullery, and every convenience for the care and comfort of the sick, making each ward, in fact, an independent hospital.

5th. They proposed that the pavilions should be separated 60 feet; the intervening space being occupied as a garden without trees or shrubs, lest the air should be intercepted, and to be used as a promenade for patients.

6th. They proposed that the pavilions should be connected by a corridor, but this corridor was not to be elevated above the basement, lest it should intercept the free circulation of air.

In these several propositions we have the germ of true reform in hospital construction. They have been approved by the highest authority both among architects and medical men in Europe and America, and are finding expression in all the hospitals now in process of erection.

> "By a hospital pavilion," says Miss Nightingale, "is meant a detached block of building, capable of containing the largest number of beds that can be placed safely in it, together with suitable nurses' rooms, ward sculleries, lavatories, baths, water-closets, all complete, proportioned to the number of sick, and quite unconnected with any other pavilions of which the hospital may consist, or with the general administration offices, except by light, airy passages or corridors. A pavilion is indeed a separate detached hospital, which has, or ought to have, as little connection in its ventilation with any other part of the hospital as if it were really a separate establishment miles away."

If the pavilion plan is rigidly carried out it will be seen that all the serious defects of the older hospitals will be remedied. The aggregation of the sick upon a given surface-area may be reduced to its minimum, and cubic air space may be increased to its maximum; the most simple and natural ventilation may be adopted for the wards; water-closets, latrines, bath-rooms, and other accessory rooms may be so isolated as to avoid all sources of impurity. Infectious and contagious diseases may be separated from the wards, containing other affections, so effectually that no communication is possible. The administration, with all its noise and sources of impurity, is entirely separated and forms a distinct and independent department.

Another, and not unimportant advantage of the pavilion plan, is its susceptibility to expansion and contraction. In its original construction, as few or as many buildings may be erected at first as is deemed necessary or expedient, and subsequently other buildings may be added as they are required. Again, the buildings being erected, any one may be vacated, cleaned, or repaired, without in the slightest degree interfering with the hospital management.

It has been alleged against the pavilion plan that it is necessarily very expensive. It is true that this form of hospital requires a large surface area, and hence more ground is necessary. And it is equally true that more buildings are needed for the separate and isolated pavilions, with all their appointments of rooms for the complete and independent service of each ward. Judging also of the comparative cost, of the pavilion and an ordinary single-block hospital, by those hospitals of each class already completed, we should, in the absence of the special facts in each case, conclude that pavilion hospitals are vastly more expensive in their construction. For example, the Lariboisière Hospital, Paris, for 650 beds, cost 6,655,215 francs, or upwards of a million and a half dollars. New St. Thomas' Hospital, London, for 588 beds, is estimated to cost £360,000, or about $1,800,000. The Herbert Hospital, England, is estimated to have cost a corresponding sum. The Free City Hospital of Boston, consisting of but two pavilions, and accommodating 225 beds, cost upwards of $300,000. The Emigrant Hospital, Ward's Island, 250 beds, cost between $300,000 and $400,000. In the instances of the two latter hospitals the expense is independent of the grounds.

On a critical examination, however, of the circumstances under which these several hospitals were built, we find a proper and sufficient explanation of the large expenditure of money in each case. Several were built at the expense of municipal corporations, and hence there was but little regard paid to economy. Others were built by wealthy organizations, which were equally lavish with their funds. In nearly all, the style of architecture was the most expensive that could be adopted, requiring extravagant ornamentation.

That pavilion hospitals may be so constructed as to give all the advantages of the plan their fullest development, with a reasonable and proper amount of artistic finish, without involving such an extravagant outlay of money as the above examples would indicate, we believe entirely possible. A large proportion of the excess in expenditure is due to architectural accessories, most of which are positively injurious, and some of which are so arranged as to defeat the very purposes for which a hospital is erected. Such are large, massive, four or six-sided towers at the extremity of each pavilion, unconnected with ventilation—curiously constructed windows, elaborately carved and heavy wood work in the interior, etc. Most, if not all, of these attempts at architectural effect are not only exceedingly costly, but tend to defeat the real purposes for which a hospital is erected.

But we need not leave this matter to conjecture, for we have an example of a pavilion hospital, large and admirably arranged, which involved no larger expenditure than one of the most common of the older hospitals. Such is the Chorlton Hospital, England. The contract for five pavilions, including the corridor, was about £3000, or about $15,000; or $75,000 for the entire hospital, which is to accommodate about 300 beds. The architect observes: "I need not say that all attempt at architectural effect has been carefully avoided; but the work is substantial and good, and the main sanitary objects will be attained."

The plan of a Free City Hospital by Dr. Henry G. Clark, of Boston, is destitute of exaggerated architectural ornamentation, but still presents a neat and cheerful appearance, with all the necessary details to answer sanitary purposes. These buildings were estimated to cost $20,000 each.

We are justified, therefore, in the assertion that a pavilion hospital may be erected at a cost not greatly exceeding the older hospitals, provided simplicity and utility guide us in the architectural designs.

The arrangement of the buildings on the plot of ground selected is a matter of the first importance. The Committee of the Academy of Sciences recommended that the pavilions should be parallel, sixty feet apart, and running east and west, so as to have one side exposed to the sun. Experience has indeed proved that the buildings should be arranged on parallel lines, but those lines should run north and south, so as to give an east and west exposure to the wards, and thus admit the sun upon both sides during the day. Miss Nightingale says "the distance between the blocks should not be less than double the height of the blocks." She adds: "A greater distance would be better; but this would involve a greater cost for land, and a greater distance to be traversed by the hospital staff." This distance of separation is not sufficient, in general, to insure proper exposure to sun and winds; and it is worthy of notice that the most recent hospitals, as the Chorlton, are built with 100 feet of separation.

Miss Nightingale, and other prominent English writers, contend that a pavilion should never have more than two stories, with the basement—giving but two wards to each. The Committee of the Academy of Sciences, however, recommend three stories, and no adequate reason has yet been given why three stories of wards may not be constructed, provided complete isolation is maintained, and the wards, water-closets, latrines, and stairways or other passages, have secured to them *separate* and *independent* ventilation. Mr. Simon (*op. cit.*) remarks:—

> "The notion that a large general hospital cannot be healthy unless it is broken into so-called pavilions, each of which shall have but two stories, has not, I think, any sufficient foundation in facts."

When the plans of the Netley Hospital were under consideration, this officer was interrogated as to whether a hospital atmosphere was liable to be generated where a large number of patients were congregated under one roof. He replied:—

> "If, by the above expression, it be meant that patients in clean, well ventilated, and not overcrowded wards, with separately well-ventilated passages and staircases, are apt to breed an atmosphere (which along passages, or through floors and ceilings, or up or down staircases, will be) dangerous to those under the same roof with them, I have no information which could lead me to accept the doctrine. * * * As regards wards kept as wards ought to be kept, I cannot conceive that the several clean items will make a dirty whole; and, so far as my present knowledge extends, I have every reason to believe that, subject to the qualifications I have stated, a given number of patients may dwell under one roof as safely as under several roofs."

The report of the Committee of the Privy Council sustains this opinion. They declare that the number of stories is a mere question of convenience, *provided* the individual wards are kept clean and thoroughly ventilated. No hospital atmosphere can then be generated prejudicial to the health of the inmates. It must be borne in mind, however, that upper wards are less accessible, and high buildings obstruct the air and sunlight.

For healthiness and facility of nursing, the number of patients to a ward has been, by common consent, estimated at about thirty. If we give to each patient the requisite surface area and air-space—that is, a surface area of 8 by 12 feet to each bed, and a cubic area of air of from 1500 to 2000 feet to each patient—the ward would be from 25 to 30 feet wide, 110 to 120 feet long, and 14 to 17 feet in height. The proportions here given are now almost universally accepted as the true basis of health and easy administration. The following table exhibits the proportions of a ward for thirty-two patients; the first column gives the proportions of such a ward in the Lariboisière Hospital; the second, the proportions adapted to a larger cubical space, such as is given in the best English hospitals:—

Proportions of Wards.	Feet.	Inches.	Feet.	Inches.
Length of ward	111	6	128	0
Breadth of ward	30	0	30	0
Height of ward	17	0	17	6
Wall spaces between end walls and windows	5	0	6	4
Breadth of windows	4	8	4	8
Breadth of wall space between windows	9	2	11	4
Height of windows	13	0	13	6
Cubic space per bed	1760	0	2100	0

It is of great importance that each bed have the requisite surface area. This well-established principle should never be lost sight of, viz.: "Impure air, whether emanating from the person or the excretions, diminishes as the square of the distance." If this axiom is constantly borne in mind, one of the greatest sources of ward infection will be removed. Miss Nightingale states that "in round numbers the superficial area for beds should be not less than 100 square feet." As the surface area of the bed is from 21 to 24 square feet, it will be seen that an additional 50 square feet will separate the beds 10 to 12 feet, allowing a proper space at the foot. An English writer on hospital construction says: "Each bed should have a space of 8 feet on the average, with 12 feet between foot and foot; beds should be at least 3 feet apart."

The amount of cubic air-space to each bed, requisite for health, depends primarily upon the activity of the circulation of the air. Under ordinary circumstances, however, it is not difficult to fix the area of each bed for a constant supply of fresh air in a room having fixed conditions of ventilation. In this problem height of ceiling has an important place, for above a certain level the stratum of air is of no service to the patient. As an example, patients crowded into churches with lofty ceilings, and close windows, have been supposed to be remarkably well provided with hospital accommodations during the late war, while those in tents have been commiserated on account of their exposed condition. But time has proved the fallacy of these speculations; the church-hospital has rapidly generated the most virulent endemics, while the tents have remained free from these affections. It is now well established that the ceiling should not be more than eighteen nor less than fourteen feet high in a hospital having proper facilities for ventilation. The cubic air-space to each bed should not be less than fourteen hundred feet.

In the pavilion plan the medium of personal communication between the several buildings must be by passageways, or corridors. In the older hospitals the corridor was always incorporated into the building, and was generally a part of the ward arrangement. Its connection with the wards varied, in some being external to the ward, but communicating with it by windows, while in others it opened directly at either extremity into opposite wards. The corridor, therefore, not only served the purposes of a passageway, but it became an important medium of ventilation of wards, and great importance was secondarily attached to it as a ventilating shaft. It requires, however, but a moment's reflection to understand that in this arrangement the corridor rather embarrasses than aids the active ventilation of the wards. When running parallel with the ward, and communicating with it by means of windows, it becomes in fact a foul-air shaft, where the air stagnates, and frequently, by the diffusion of gases, this stratum of foul air again returns to the ward. The corridor also, by communicating directly with two or more wards having deficient ventilation, allowed one ward to ventilate itself into another, and thus they became the means of a general contamination of the whole hospital.

In the pavilion plan this defect may be completely remedied. The corridor becomes the medium of communication between buildings, but stands independent of those buildings, and especially of the wards. But even this separation is not sufficient; the corridor should, like the wards, have a separate and independent ventilation, so that by no possibility can it become the receptacle of foul and stagnant air. This can only be effected by constructing it with arcades, so that it is entirely open upon either side.

If there are two stories of wards, the corridor should have but one story, with its basement. The basement should be low, and the story should be open by means of arcades. By this arrangement the most complete ventilation of the corridor is obtained, and there is no possibility of the communication of the air of one ward with another, through this passageway.

Another and important argument in favour of having the corridor with open sides is that the circulation of the air upon the grounds is left free and unobstructed. As the corridor connects the adjacent pavilions, it necessarily traverses the intervening plot of ground. If, now, the corridor is high and closed, it very seriously obstructs the circulation of air around the buildings and through the grounds. The result of this stagnation of air on the plot of ground between the pavilions is deficient ventilation of the wards when that ventilation is by means of windows, and, what is more serious, there must be established, by the diffusion of gases, a process of slow ventilation of one ward into another, one of the most serious defects of the older hospitals.

One of the greatest sources of impurity in older hospitals is the water-closet. Its location is generally so nearly in the centre of the block, that all its emanations pervade not only the adjacent ward, but also the whole building. The pavilion enables us not only to isolate the water-closet and urinal from the hospital, but also to effectually separate them from the ward, while they are still sufficiently near for all practical purposes. Even more, it enables us to provide them with a separate ventilation. These accessories to the ward should be placed at the end of the building furthest removed from other departments of the hospital, and, being supplied with an independent drain, all foul material is immediately conveyed from the grounds. The position of the water-closet also admits of thorough ventilation, independently of the ward or stairways. The water-closets and sinks should also be located in the extremity of the building opposite the entrance and nearest the external limits of the grounds. In their construction they should be placed along the outer wall, and separated by a well-ventilated vestibule from the ward. This may be effected in various ways, but the best plan is undoubtedly that given by Miss Nightingale, which very effectually answers the purpose of exclusion and thorough ventilation.

The proper place having been selected for locating the water-closet, the question recurs, What form shall it have? The bowl with a movable pan is always objectionable in hospitals, as patients will use them so much and so roughly that they soon get out of repair. The pan can, however, be dispensed with, provided there is a free flow of water, with an invariable downward current of air. The former condition can be secured by allowing the flow of the bath-room and scullery into the water-closet, and the latter, by connecting the soil-pipe with a heated shaft, as a chimney. In the lunatic asylum at Utica a strong downward current is created by the comparatively large size of the soil-pipe—which runs from the sewer below directly upward and opens above the roof—and the pressure of the atmosphere within caused by the fan. It is the opinion of Dr. Gray, the distinguished superintendent, a precise and accurate student of ventilation, that the downward current is solely due to the large size of the pipe, but we are disposed to attribute something to the pressure of the volume of air which the fan creates. In this admirably conducted institution the water-closets are arranged centrally in the block, the bowl standing out in the middle of the closet, without any surroundings, and yet there is not the faintest foul odour perceptible, though fecal matter may be present on the sides of the bowl. This seems to be the perfection of water-closet arrangements, and cannot be too strongly recommended where downward ventilation can be secured. In general, the common trough with a large outlet closed by a plug, is the cheapest and most cleanly apparatus.

In the construction of the exterior walls of a hospital economy and simplicity would suggest the employment of brick. Whatever style of architecture is adopted, brick can be made to assume all the artistic finish of the most polished stone. But the selection of the material of the exterior wall is entirely a matter of economy and taste. But far different is the question of the character of the internal wall. Here we have to study the effects of hospital miasms upon the materials which surround the sick, and select the substances which enter into the walls, floors, &c., with especial reference to this result.

The great desideratum in this construction of the interior of hospitals is an impermeable material for the walls. The examples are now numerous where hospitals have become uninhabitable owing to the infected condition of the walls. The old English Dreadnought Hospital ship, the walls of which were white-washed wood, had to be abandoned owing to the severe endemics of pyæmia, erysipelas, &c., which prevailed in its wards. On the substitution of a new ship, the Caledonia, these affections almost disappeared, but after this latter ship had been in use seven years the same diseases became again prevalent. There can be no doubt, therefore, that the miasma of hospitals will cling to the walls if they are composed of permeable material, and that it is extremely desirable to have them made of some non-absorbent material like glass, and which may be as readily and effectually cleaned. The impropriety of the ordinary plastered wall with hair, is evident. The material now more frequently recommended abroad is Parian cement, which is non-absorbent, and may be thoroughly cleansed, and also glazed tile. Stucco is used in the new Parisian hospitals and gives satisfaction.

It is important, also, that the windows and doors should be as free as possible from absorbent wood-work, and that the wood-work should be reduced to the smallest amount compatible with the proper construction of these passageways. Instead of massive and jutting cornices the wood-work about windows and doors should consist of a mere framework of wood, and that should be so prepared as to be non-absorbent. By waxing and polishing, the wood may be rendered impenetrable.

The floors like the walls should be non-absorbent, and for this purpose waxing and polishing are found to answer the best purpose, the wood being properly chosen. The yellow pine of Florida answers an admirable purpose, as employed in the Pennsylvania Hospital for the Insane. The floor being made of proper material, dry scrubbing should always be practised instead of wet. Vapour in a ward always tends to collect the miasmatic emanations and diffuse them more widely.

Miss Nightingale recommends for the wood-work of wards polished or varnished wainscot oak. "It is the cleanest, most durable, and most satisfactory in use." The reasons of her preference is that oak is more non-absorbent than other wood, but she advises that even this floor should be saturated with beeswax and turpentine. She also states that a hospital floor should be fire-proof by having the joints inlaid with concrete.

In the construction of stairways stone is preferable to iron or wood, the former being readily kept clean, and effectually preventing the noise of those passing over it. This advantage of stone is seen in the Pennsylvania Hospital for the Insane. The stone is of a dark colour—a slate, but very durable—obtained cheaply at Middle Granville, Washington Co., New York. The stairway, as a whole, should also be fire-proof. The same stone could be advantageously used in the halls and corridors both for cleanliness, durability, and to prevent noise.

One of the most difficult questions to determine in hospital construction is, How shall a constant and unfailing supply of unadulterated air be supplied to the sick and still preserve the conditions necessary to personal comfort? Various are the theories that have been suggested by the curious, and ingenious the contrivances to meet this great want. But if we are governed by the opinions of the best authorities, the problem still remains unsolved. No system of artificial ventilation has yet been devised which could meet the conditions above stated. Their almost universal testimony is adverse to all schemes of forced supply of air. "We have no faith," writes an eminent English architect, "as we have often said, in simply scientific ventilation for hospitals. The necessity for artificial ventilation implies, we think, a defect in plan."

Mr. John Roberton, of Manchester, England, says, in his pamphlet on Improvement of Hospitals:—

> "I repeat what I formerly stated, that so wide is the difference between the wants of a ward filled with the sick and wounded with respect to ventilation, and the wants of every other kind of apartment in which people in health congregate or lodge, that the means which are found sufficient to maintain the purity of the one fail in maintaining the purity of the other."

Equally emphatic is the language of Miss Nightingale in reply to the Barrack Commissioners: "If a hospital must be ventilated artificially, it betrays a defect of original construction which no artificial ventilation can compensate. It is an expensive and inefficient means of doing that which can be done cheaply and efficiently by constructing your building so as to admit the open air around."

The Committee of the English Privy Council appointed to visit for purposes of sanitary inquiry the hospitals of Great Britain report:—

> "We have no hesitation whatever in expressing our opinion, founded in all cases on observation and such an examination of recorded facts as we have been able to make, that every pound (and they have unfortunately been many thousands) which has been expended on these costly and elaborate machines (for artificial ventilation), has been wasted. The example of Guy's Hospital is familiar to all medical men in London, and the superiority of the old wards with natural ventilation to the new ones connected with the artificial system, is an admitted fact. * * * These systems (at least those on the principle 'par injection'), do no doubt keep up a constant supply of air to the wards, yet they do not ventilate them."

The Society of Surgery, of Paris, in their recent discussion on Hospital Hygiene, state among their conclusions that artificial ventilation can never supply the conditions of healthiness to a ward.

The Lariboisière Hospital, Paris, is brought forward by the opponents of artificial ventilation as a melancholy example of the total failure of this system. Constructed according to plans now universally recognized as correct, it has as yet given a higher rate of mortality than the average of the Paris hospitals. And this insalubrity is attributed to the substitution of artificial for natural ventilation. It is stated that the expense of constructing and working this machinery in that hospital amounts to about $100,000 for construction, and about $10,000 a year for working, to ventilate a hospital of 600 beds.

Mr. Simon (*op. cit.*), one of the most eminently practical hygeists of the present day, says:—

> "Hitherto, I believe without exception, plans of artificial ventilation for wards have been costly and fatal failures. And in the present state of knowledge, the utmost that can be said for them is that some of their appliances (specially those for the withdrawal of used air), may advantageously be used as additions to that more natural ventilation which, at least in this country, has appliances provided for it in the common conditions of decent house construction."

A late writer thus speaks of the system of artificial ventilation in use at Guy's Hospital, London:—

> "At Guy's Hospital may be seen an immense tower, serving as an air shaft for an elaborate system of ventilation, which attracts the admiration of all engineers, and has received medals of honor from exhibition juries, but which makes the wards no healthier, or rather leaves them much inferior in salubrity to the original wards that trust solely to natural ventilation. This system either is, or will be, or at least might as well be entirely disused. We venture to think that if the complete success which has attended the practice of hospitals in which no such machinery is found had been publicly known, this great waste of the hospital resources would not have been incurred."

Natural ventilation, as distinguished from artificial ventilation, is that which is obtained by means of windows, doors, and open fireplaces. The air instead of being forced through rooms and passages against obstructions, is drawn by those natural agencies, and currents flow continually and with large volume wherever they are required. To accomplish this object the wards should be narrow, the windows large and arranged directly opposite each other, the fireplaces large and well open, etc. The great object is not only to furnish currents of fresh air through the ward, but to flush the floors and ceilings, and to effectually sweep the corners of a stagnant atmosphere. This can only be done thoroughly by windows and doors, and the former must be so arranged as to afford the largest and most direct flow of the external air. The windows should be as numerous as is consistent with the safety of the wall, and extend from the very ceiling to within a few feet of the floor. The fireplaces should be in sufficient numbers to warm the wards effectually, certainly two, and if necessary three, as in the Chorlton Hospital.

In the Stewart Hospital (Richmond, Va.), the fireplaces were four in each ward, arranged in pairs, back to back, in the centre of the ward. These fireplaces were old fashioned, very high, broad, and open. This hospital had been remarkably free from endemic diseases. Miss Nightingale says, "Our grandfathers' lofty fireplaces are the greatest loss in modern house architecture. The little low fireplaces of this date bring the best current of air below the stratum in which we are breathing."

In regard to the comparative value of natural ventilation, the English Privy Council's Committee report:—

> "No amount of cubic feet of space, no plan of building, no artifical system, no combination of all these adjuncts to a good ventilation, has ever been found

> to replace open doors, windows, and fireplaces: while provided with the latter, which are the essentials of good ventilation, many old crowded defective hospitals have maintained for a long series of years an amount of success which the most eminent examples of scientific construction have never found practicable. Considering, then, the utter failure of artificial systems and the perfect success of the natural system of ventilation, is it going too far to say that to expend money in the construction and in the maintenance and working of such machinery could, after our present experience, be wantonly to waste and misapply the funds contributed for the benefit of the poor?"

Mr. Simon (*op. cit.*) remarks upon this point:—

> "Open windows and (as substitutable for them in certain states of the weather) other direct, but less drastic air-holes through the walls of the ward, are at present the essential *inlets* for fresh air. They also, under many circumstances, are the *outlets* for the used air; but in this function chimneys co-operate with them, acting where fires are alight, very serviceably as outlets; and it never can be otherwise than advantageous to the ventilation of a ward that subsiding shafts should give a greatly increased development of that ordinary chimney-action. For in ventilation, then, our reliance must be upon direct air-holes—of which open windows are the chief; on these same means we must also, under ordinary circumstances of construction, rely for a large share of out-ventilation; and thus, whatever other appliances exist, a ward must be perfectly ventilable by its windows."

While strongly advocating the introduction of natural methods of ventilating to every portion of the hospital, and of heating wards by means of fireplaces, it is not to be understood that artificial methods of heating are altogether discarded. What authorities insist upon is, that all artificial methods of heating shall be subordinate to the grand idea of ventilation by natural means, viz: fireplaces in use, windows, doors. And the same remark applies to the employment of additional means of ventilation. Whatever they may be, they should be but accessories, never principles in ventilation. This opinion is forcibly pressed by the Committee of the Privy Council (*op. cit.*):—

> "We do not intend to assert that artificial ventilation or artificial heating do any harm if applied to wards which are kept healthy by the use of the natural means of ventilation. * * * We have a strong conviction that where such machinery is used as a substitute for natural ventilation and open fireplaces, it will produce the most deadly results, and this conviction is founded on what we have learnt both at the Parisian hospitals, where such systems are still in use, and at the British hospitals, where (when used as they are in Paris) they have all failed to stand the test of practice, and have been given up."

It must be remembered that the above opinions are given by foreign authors, and that the method of ventilation so strongly urged, is adapted to a mild climate. It is very questionable whether, under any circumstances, natural ventilation can be entirely relied upon in more rigorous northern winters. Indeed, from our own personal examination of different methods of securing natural and artificial ventilation in the hospitals of this country, we are convinced that the two must be combined, the former being resorted to in the summer and the latter in the winter. The fan is, perhaps, more generally employed than any other apparatus, and when due regard is had to the heating of the air, and the inlets and outlets in the ward, it serves an admirable purpose. In the State Insane Asylum, at Utica, New York, Dr. Gray has introduced the fan, and so graduated the volume of in-coming and out-going air of the ward that a decided pressure is constantly exercised upon the contained air of the ward. This pressure is such as to move the air in endless currents, and renew the entire volume with remarkable frequency.

The central administrative building should stand so related to the pavilions as to preserve complete isolation, and yet economize distance. One of the principal objections alleged against the pavilion plan is the wide separation inevitable between the administration and the wards. This, however, is not absolutely necessary, as may be seen in the Rhode Island, the Emigrant, City (Boston) Hospitals, &c. &c. The administrative building should have a central position, and be so related to the corridors as to afford easy access to all the wards. It should be exclusively devoted to administration, and should contain only the officers' apartments, the offices, the governors' rooms, &c.

The kitchen is frequently located in the basement of the central building, but it is better to give it a separate position. It should be light, well-ventilated, and its walls should be constructed of materials which will not be affected by steam and which are non-absorbent. The floor should be of stone—slate of very large size.

The wash-house should be separated from all the other buildings, when practicable, as it is the receptacle of the foul linen and infected clothing. It should have perfect through-and-through ventilation, and the walls and floors, like the kitchen, should be of non-absorbent material.

The operating room is too often located in the upper story of the hospital. It should be most accessible from all the surgical wards. For this purpose it should be near the centre, and on that floor nearest the surgical wards. It should be well aired, well warmed, and have the light directed upon the table from above as well as from the sides. It is well to have a large bathing tub at hand, or in an immediately adjoining room, which can at a moment be supplied with hot water, as in the Boston Hospital, for accident cases in collapse. It is well, also, to have small wards adjoining the operating room into which severe cases can be temporarily placed before or after an operation.

The application of the foregoing principles to hospital construction are evident. The striking defects in the arrangement of the older hospitals were that the wards ventilated into each other; corridors and stairways were ventilating shafts to wards; water-closets, sculleries, and other accessory rooms were indifferently ventilated into wards or into each other. It is now apparent that the utmost hospital unhealthiness was created by this method of construction. The remedy for this defect consists in a separate and independent ventilation for each department, that is, each has its inlet and outlet of air without connection with others. In the first place, there should be a free circulation of air completely around the building. No building, or trees, or other obstructions should be allowed to intercept the currents of air. All adjacent buildings, as pavilions, should be so separated that they cannot obstruct the winds. The ward should run north and south, or nearly so, in order to have an east and west exposure.

These principles are inculcated by the highest authorities. Says an eminent English writer:—

> "There must be no stagnation. A court, with high walls around it, does one thing with certainty—it stagnates the air and renders it unfit for respiration. All closed courts, narrow culs-de-sac, high adjacent walls, closed angles, overshadowing trees, and other obstructions to outer ventilation should be sedulously avoided at whatever cost. * * * The most simple form of structure for insuring ventilation and light is to build hospital wards in a straight line, with windows on both sides."

The ward should be as narrow as can be compatible with its special arrangements for the purposes of bringing its opposed windows near together.

The windows should open directly into the free air; they should be arranged directly opposite to each other; they should be as numerous and as large as the wall will admit and as convenience will require; they should reach from the ceiling to within a few feet of the floor; they should be square at the top. Double sashes may be provided to prevent too free ingress of air, or an extreme upper portion of the window may be made to open separately. Open fireplaces should be constructed at proper points of the ward for the purpose of both heating and ventilation.

Mr. Simon (*op. cit.*) remarks:—

> "Hospital construction has *pro tanto* failed in its first obligation if the form and arrangement of wards, and the distribution and planning of windows be not such that each separate ward (independently of all other wards, and of all staircases, passages, corridors, and offices) shall admit of that kind of ventilation in its completest possible form. An oblong ward from 25 to 30 feet wide, windowed correspondingly on its two long sides with sash windows reaching to the top, and windowed in such proportion to wall that between each two windows there shall be the required space for one bed-head, and having its communications and separately ventilated offices at its two ends; this, by common consent, is the form of ward which best of all answers the proposed purpose. And in proportion as this form is departed from, in such proportion, sooner and sooner, will the limit of the ward's usefulness be reached—the point, namely, at which ventilation will prove insufficient—the point at which typhus will spread from bed to bed, and at which traumatic infections will arise among surgical cases."

In the second place, the water-closets, bath-rooms, sculleries, &c., should not only be separated from the ward, but they should have a separate ventilation so perfect that their emanations can under no circumstances penetrate the ward. This can be effectually accomplished in the pavilion, and still have each room or apartment entirely serviceable to the patients. The proper method of isolation requires that these accessory rooms should never communicate directly with the ward, but by passages which are ventilated by opposing windows. Each apartment should have, in addition, its own inlets of fresh air and outlets of foul air.

The corridor and stairways should also be independent of the ward and of each other. The corridor should be so open that it can never be the receptacle of foul air, and can never obstruct the circulation of the grounds. This may be effected by arcades. The stairways should equally have their opposing windows, with a through ventilation, so thorough and constant that no stratum of air can stagnate.

In conclusion we would enforce the maxim of the British Barracks and Hospital Commission, viz., the objects "sought in the construction of a hospital is the recovery of the largest number of sick to health in the shortest possible time, and to this end everything is only subsidiary." In this proposition we have the groundwork of substantial reform, and until it becomes the ruling principle with architects and all interested in these institutions, hospitals will not fulfil their true mission. Hitherto we have studied too exclusively architectural effect, and in our zeal to vie with other public buildings, have lost sight of the humble and sacred purpose to which a hospital is dedicated. If richly carved work, fanciful windows, imposing towers, etc., were essential elements in the successful treatment of the sick, the former style of hospital architecture would admirably serve the purpose of life-saving. But when we recall the fact that the largest success in the treatment of the most dangerous and fatal forms of disease is in the simple tent on the open field, we fully realize how vain, indeed, how criminal, is the expenditure of money in merely architectural extravagance.

S. S.